

ART. XI.—*Notes on the Geology of the Country about Anglesea.*

BY T. S. HALL, M.A., D.Sc.,

University of Melbourne.

(With Plate XI.)

[Read 9th June, 1910.]

The hamlet of Anglesea lies near the mouth of the so-called "river" of the same name, eight miles in a direct line south-west of the mouth of Spring Creek, the typical locality of the Jan Jukian beds of the tertiary series. The old name of the Anglesea River was Swampy or Salt Creek. Six miles further to the south-west, Airey's Creek enters the sea at Airey's Inlet, and from here eight miles away across Loutit Bay, the houses of Lorne may be seen nestling on the wooded flanks of the Otway Hills.

Previous references to the geology of the district are scanty. Daintree in 1863, after briefly discussing the section displayed at Bird Rock, mentions, half-way between Point Addis and Jan Juc, the presence of cliffs of sands, black with carbonaceous matter. In them, he says, "a remarkable instance of the preservation of fossils occurs. All the large imbedded shells are entirely decomposed, and where their casts remain they are imperfectly rendered in iron pyrites, whilst minute foraminiferae, abundant in the rocks, are preserved intact." He does not say whereabouts in his series he would place these beds.

Krausé, in 1874, after a very hurried survey, roughly mapped the Cape Otway District, and several notes are given on the coast between Spring Creek and Point Castries, where the tertiaries thin out on the Jurassic strata. A few corrections in detail are required. Thus the dips given are usually the apparent, and not the true ones. A creek is shown entering the sea on the east side of Point Addis, and another about a mile east of Salt Creek (Anglesea River), though neither of these

exist. Still, the map is useful as far as it goes, and, considering the amount of ground Krausé had to cover in the time allotted, the result as a whole is one we must thank him for.

Mr. J. F. Mulder, in 1893, gave a list of a dozen species of fossils from the Airey's Inlet limestone, but added nothing further to our knowledge.

The coast between Spring Creek and Rocky Point, a distance of about two and a-half miles, has been briefly described by Professor Tate and Mr. Dennant in 1893 and 1895. Mr. Pritchard and I also discussed the relationships of the same beds in 1896.

Mr. A. G. Campbell, in a short sketch of the botany and geology of the coast between Point Addis and Anglesea, mentions the "tall cliffs of mud-like material," and refers to "somewhat similar beds beyond Anglesea, containing fragments of volcanic scoria to the size of a football, and an occasional waterworn basalt pebble," and thinks that "these clayey cliffs mark the proximity of once-extensive lava-fields, long since disappeared."

The fossiliferous yellow limestone of Rocky Point continues along the coast to the south-west for about the third of a mile, and on rounding a small point it is seen to overlie purple and black, sandy clays, and to dip E. 10 degrees S. at 5 degrees or 6 degrees. The inward sweep of the bay has cut out the limestones from the cliff face, and inland they have been removed by denudation, their thickness being small. A couple of miles further on Point Addis forms a low but prominent headland, which is capped by the same limestone to a thickness, according to Krausé, of 60 feet. Between Point Addis and the previously mentioned point three reefs occur in the sea, which are in a straight line, and evidently are due to the induration of bottom beds of the limestone.

The Point Addis limestones are yellowish in colour, and in places very concretionary and ragged. Quartz sand of a roughened, granitic character is of frequent occurrence, and at times forms thin bands. Indurated bands and patches are common, and the rock is in places quite crystalline, a character previously referred to by Mr. Pritchard and myself, and believed by us to be due to the impervious sandy clays on which the calcareous series rests. The variety of fossils is small, but

the locality is remarkable for the extreme abundance of *Cassidulus australiæ* (Duncan), while *Magasella compta* (T. Woods) is almost as plentiful.

The purple and black clays, which are seen in cliff section to underlie the limestones, are weathered to a lighter hue in their more superficial parts, and it is chiefly to this weathering that the various beds measured by Krausé, and recorded in a note on his map, are due. This section is the one previously mentioned by Daintree as containing pyritic casts of mollusca and unaltered foraminifera. I have never carefully searched for fossils, and have seen none in the beds. Daintree evidently regards the black beds as the equivalent of the marine series of Bird Rock, though he is not clear on the point. On rounding Point Addis, and traversing half a mile of sandy beach, a small point is met with, consisting of ferruginous sands, and quartz conglomerates. This is known as the Black Rocks. From here to the mouth of the Anglesea River the coast is marked by vertical cliffs of black sandy clays. These beds are similar to those on the other side of Point Addis just referred to, and are of a very striking character. Beyond the mouth of the river, after passing a small strip of sand dunes which mark the extent of oscillation of the mouth, we encounter an outcrop of ferruginous conglomerates and sands interbedded in the black sandy clays, but of only small lateral extent. They form a small point on the beach, and are very similar to those at the Black Rocks. The sands and clays form cliffs of gradually lessening height from here to the shoreward end of Point Roadknight, which is formed entirely of dune limestone.

At the mouth of the Anglesea River the older tertiary forms the east bank, and a hard outcrop occurs on the beach. It also forms a reef bare at half tide a short distance off shore, while another reef of perhaps a similar character, the "Hereford Reef," from the name of a ship wrecked on it, occurs a mile to the east. Banked against the older rock at the river mouth are a few small patches of indurated sand forming a small raised beach. In this I found several paired valves of *Chione scalarina* in the living position, and some large examples of *Lampania australis*. Krausé, on his map, marks "sandy limestone" here, and probably refers to this small outcrop.

The black, sandy clays between here and Point Addis are weathered to a fawn colour in their upper part, and the change to purplish black is rather sudden. As the weathering follows the contour of the ground, the beds appear to form a gently swelling anticline, with the lower beds showing to a thickness of about 40 or 50 feet in the middle of the section. An examination, however, shows that the appearance is deceptive, and is merely a colour effect.

The chief peculiarity in the black series is its jointing. In one place not far from Anglesea rectangular prisms, with a four or five inch face, are developed, the joint faces being vertical. In other places, and far more commonly, great sheets flake off the vertical cliffs and fall or hang in threatening positions nearly a hundred feet above the beach. Still nearer to Point Addis, for over half a mile, the cliffs, here about 150 feet in height, form a confused mass of tumbled heaps. The dip of the undisturbed strata is small, but holds steadily to seaward along the straight coastline, and great masses have apparently glided down the dip-slope and formed the landslips. The dip can be seen along the shore towards Point Roadknight, and on a small point a couple of miles west of Point Addis.

The siliceous grits which were noted in the lower part of the Addis Limestone also occur in the underlying series even down to the lowest part of the black beds. They seem to grow coarser near the top of the cliffs, and small beds of waterworn quartz-gravel occur frequently here, near where the limestone probably once lay before its removal by denudation.

In the black, unweathered beds seams and small nodules of iron pyrites are of common occurrence. The weathering of this into copiapite was noted by Daintree, while near Point Roadknight alum occurs as an incrustation which has a greenish tinge.

Remembering Daintree's record of pyritic casts from the beds near Point Addis, I searched for a long time near Anglesea for fossils in these barren beds. The occurrence of lignitic fragments, which are fairly common in places, gave me the idea that perhaps the beds were, after all, of freshwater origin, but later on this idea was dissipated by the finding of a tooth of *Odontaspis contortidens* Ag., and numerous examples of fora-

minifera, as recorded by Daintree, and mentioned above. These have kindly been identified by Mr. F. Chapman. I found no pyritic casts of molluscan or other shells.

The oxidation of the pyrites has evidently given rise to the limonite, or at times haematite, which had cemented the sands and conglomerates at many exposures; for instance, the Black Rocks, near Point Addis, the similar rocks half a mile west of the river mouth, and the ironstone hill on which the Anglesea Hotel is built. Similar ironstone conglomerates occur on the river banks higher up, and at many places on the roads leading to Jan Juc and Airey's Inlet. Moreover, wells sunk at a farm a mile inland up the valley yield water so highly mineralised that it is useless for stock or for garden use, probably from dissolved sulphates.

A mile west of the mouth of the river, the face of the cliffs, which rapidly decrease in height as we approach Point Road-knight, are occupied by extensive landslips, which are well overgrown by trees at their northern end, but broken and crevassed along the sea front, and evidently have moved quite recently, as the surface is bare of vegetation. An examination of the cliff face shows that the overlying sandy strata have moved over a clay bed of a peculiar nature, which passes below sea level with a steady southerly dip. The bed of clay, which is about twelve feet thick, when traced easterly soon runs up to the top of the cliff, and cuts out at the top, the cliff being about 80 ft. high. The underlying beds are evidently the representatives of the black series further east, but are bleached to a greyish hue. Hereabouts they are protected by Point Road-knight from the rapid wearing by the sea, and there is time for weathering to act on the face, while further eastward the unsheltered cliffs are rapidly cut back.

The clay bed mentioned above is, as already stated, about twelve feet in thickness. Its ground mass is bluish grey, and scattered through it are white angular pieces of clay, rarely more than an inch in diameter. On tracing the bed to a small point, which can be passed round at about half tide, we find it has slightly altered in colour, being of a greenish grey hue, and is carved into small pinnacles and chasms by the waves. The whole mass can be cut easily by the knife, but

here and there fragments of what appear to be basaltic scoria are to be found. They are, however, quite decomposed to clay, and only the weathered face gives any clue to their nature. Search among the pebbles at the foot yielded a few fragments of dense basalt, which may or may not have been derived from this bed. The clay conglomerate contains a few quartz pebbles, and sand grains are common, while a few rock fragments occur which all seem to be derived from rocks similar to the underlying series, and of tertiary age.

The great bulk of the bed is evidently made up of fragments of a basaltic rock, and I feel convinced that it is a tuff. The thick tuff beds associated with the Airey's Inlet basalt are, it may be mentioned, only about three miles away along the coast. Mr. A. G. Campbell, who noticed the basalt fragments about here, believed that the bed was derived by denudation from a basalt flow.

If the clay bed be really a tuff, it then throws interesting light on the Spring Creek series, as well as on that of Airey's Inlet. To this I shall refer after a short description of the latter.

In walking to the westward along the coast from Point Roadknight, we see very little but sand dunes for about three miles, when we encounter cliffs of yellowish and drab tuffs. Overlying these is a series of ferruginous sands and gravels. The tuffs are splendidly shown in cliff section for a couple of miles to a thickness of from 20 to 30 feet. They vary much in the size of the component fragments, and are very much decomposed. In places basaltic fragments up to two feet in diameter are common, together with fragments of sandstone and shale of doubtful age. Near Eagle's Nest solid basalt forms the base of the cliffs, and underlies the ash beds. As a rule the basalt is black and dense, but occasionally its upper part is vesicular, and filled with amygdules of lime. It is possible that a careful examination of the dip of the tuffs may fix the site of the vent which cannot be very far away, if we may judge by the size of the included fragments. It is probable that it lies out to sea.

The upper surface of the basalt has been deeply denuded, and on this worn surface lie the Airey's Inlet Limestones. These

are yellow detrital limestones, very similar to those of Point Addis in every way. Quartz grains are plentiful, and the same fossils occur, polyzoa making up the bulk of the rock. At Split Point the surface of the underlying basalt is cut by channels, and is very bouldery, so that the limestone forms deep pockets, and in cliff section islands of limestone appear in the basalt, the connection with the overlying beds being not always shown. Some of these pockets go down twenty feet below the main mass, and in them the rock is quite unaltered and similar to the massive beds above, so that fossils may be easily picked out. Where the limestone overlies the ash beds it is generally changed to a pink crystalline rock of varying thickness.

As pointed out some years ago by Mr. Pritchard and myself, the contact of the limestone and basalt is a repetition of what is found near Maude, a feature which struck us when we visited Split Point in 1894.

The Jurassic rocks of the Otways come in on the shore line near Point Castries, about four miles further to the south-west, and between Point Castries and Airey's Inlet occurs a series of beds which are clearly of tertiary age, but whose relationships to the beds further east has been matter of doubt. They have been described in some detail by Krausé, since, close to the Jurassic, they contain small lignite seams. They are as a rule very sandy, and in places quartz gravels occur, and at Point Castries Krausé notes black clays resting on the Jurassic.

It seems almost certain that these western beds represent the black beds of Anglesea, and are of fresh water origin. As we go north-east along the coast, the influence of marine conditions is more strongly felt, and near Anglesea marine fossils, as mentioned, are sparingly found. Still further on the character of the beds beneath the yellow limestone changes: gravels and grits disappear, and at Rocky Point marine fossils of all kinds are common, the beds becoming richer as we approach Bird Rock. The limestones of Airey's Inlet (Split Point), Point Addis, and about the mouth of the Jan Juc Creek, seem to be on the same horizon, as the echinoderm fauna at any rate appears to show.

If the bed described near Point Roadknight be indeed a tuff, as I am strongly inclined to think, then it is almost certainly

a part of the Airey's Inlet tuffs, and these are, if my inferences be correct, contemporaneous with part of the Spring Creek lower beds or of Jan Jukian age, and to the same series must be referred the beds between Airey's and Point Castries.

Krausé has marked on his map, and described in his notes a division between a lower series of rocks which he calls Miocene, and an overlying series which he calls Pliocene. The "Miocene" is mapped only along the sea coast, with an extension up the valley of Spring Creek, owing to the removal of the overlying "Pliocene," but I do not know on what this subdivision rests, and am unable to see any justification for it.

Physiographically the country between Geelong and Anglesea is a coastal plain, with a mean elevation of perhaps two hundred feet. From west to east across this a broad valley, five or six miles wide, has been excavated, and subsequently partly flooded by a series of lava flows of "upper volcanic" age. This valley is drained mainly by Thompson's or Bream Creek. The lava is a tongue from the western plains, and comes down the Barwon Valley from the south of Winchelsea. The River Barwon turns abruptly north near this town, but probably its old course was along the wide, mature valley now occupied by the lava flow, which enters the sea as a broad flood between the mouths of the Barwon and Bream Creek.

As this valley is excavated in sandy beds which crop out extensively along its margin, it is evident that a considerable part of the rainfall is probably absorbed, and sinks below the basalt. This being the case, it seems almost certain that a line of bores across the lava stream would tap a supply of underground water, which would be of value in augmenting the deficient summer supply of this area. As is usually the case in basaltic country, what streams there are, are highly mineralised, and the dissolved salts flocculate the suspended clay, and so cause its precipitation, leaving the water clear, and an object of suspicion to the traveller. The old bush maxim is justified which says, of two streams choose the muddy one as being probably better water.

The coastal plain is sandy, and the soil is extremely poor, so that the timber which grows on it to the south of Jan Juc affords only second-rate firewood, and is fit for little else. As

we approach the plateau near Anglesea from the lava-floored valley, the heights are rather striking, and are dignified by the name of the Anglesea Ranges. Once on the plateau the coast road easily avoids all valleys, and runs level till the Anglesea Valley is reached. This near its mouth is about three miles wide, and is trenched to a depth of about 200 feet. Towards Airey's Inlet the elevation increases as the beds begin to rise on the flanks of the Jurassic, and the streams have greater cutting power, and are more numerous, so that broad stretches of level country are less frequent.

Airey's Inlet is curiously named, for there is no inlet from the sea; the small creek is usually barred completely by sand banks, but was possibly opened by floods at the time it was named.

The valley of Spring Creek is a modern one, and is steep-sided near the township of Jan Juc, where a fairly fertile soil is derived from the waste of the earthly limestones exposed.

I give a list of the fossils I have identified from my gatherings at Point Addis and Airey's Inlet (Split Point), and quote their Spring Creek record:—

	Airey's.	Addis.	Spring Creek.
<i>Paradoxechinus novus</i> , Laube	1	1	1
<i>Monostychia australis</i> , Laube	1	1	1
<i>Scutellina patella</i> , Tate	1	1	1
<i>Fibularia gregata</i> , Tate	1	—	1
<i>Cassidulus australiae</i> , (Duncan)	1	1	1
<i>Eupatagus murrayensis</i> , Duncan	1	1	1
<i>Eupatagus rotundus</i> , Duncan	—	1	1
<i>Duncaniaster australis</i> , (Duncan)	?	—	1
<i>Pentagonaster</i> sp.	—	1	—
<i>Terebratulina catinuliformis</i> , Tate	1	—	1
<i>Magasella compta</i> , Sow.	1	1	1
<i>Dimya dissimilis</i> , Tate	—	1	1
<i>Pecten hochstetteri</i> , Zittel	—	1	1
<i>Spondylus gaederopoides</i> , McCoy	—	1	1

There is thus an almost complete identity of fossil contents, and the beds are on the same horizon.

